Newton's First Law (N1L)

An object maintains a constant velocity unless acted on by a <u>net</u> outside force.

↑ total

No net force: <u>equilibrium</u> (forces cancel)

Static equilibrium:

no net force

$V = 0$

(no motion)

Force i a push or a pull

Units: Newtons

$$1\,N = 1\,\frac{kg\,m}{s^2}$$

Types of Forces

- **Weight** W

  force of gravity on object

  units : Newtons

mass m : amount of stuff an object has

on Earth, $\boxed{W = mg}$

$g = 9.8\ N/kg = 9.8\ m/s^2$

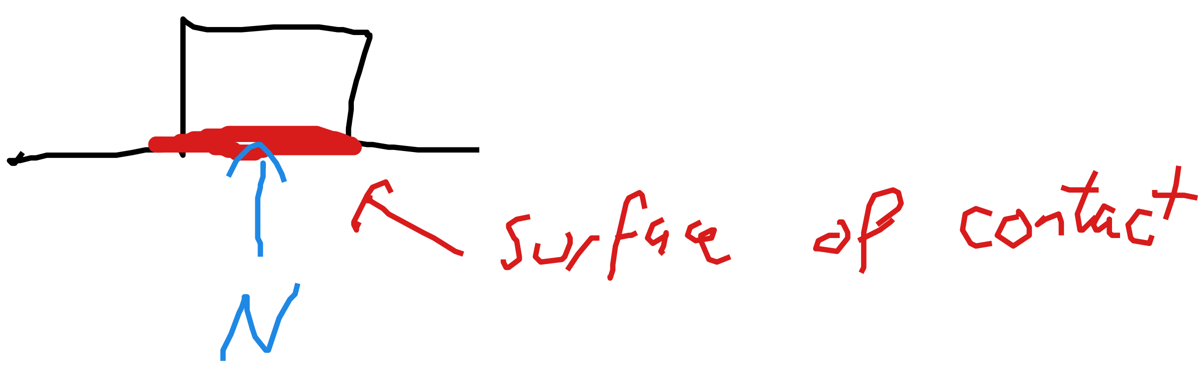
Pounds (lbs) are unit of force not mass

$1\ lb = 4.5\ N$ $\quad 40\ N \sim 9\ lb$

- "Adjustable" Forces
  - unless given, take whatever force is necessary to maintain equilibrium

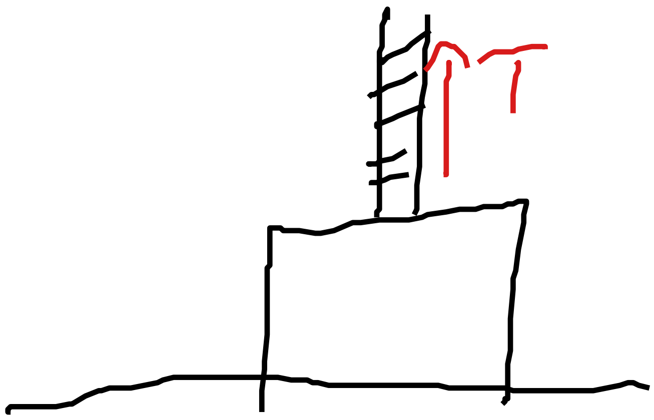
- Normal force N
  - a "push"
  - ⊥ to surface of contact

"normal" = "perpendicular" ⊥



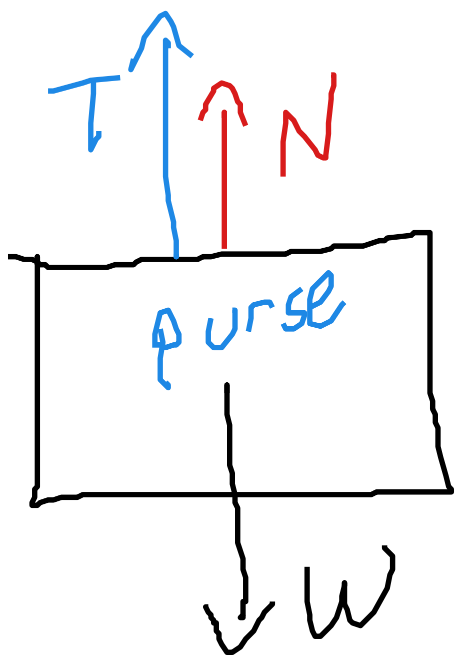
- Static friction S
  - resistance to sliding
  - parallel to surface of contact

- Tension T
  - "pull"
  - usually along a rope etc



Force Diagram

- start with object of interest



purse being pulled up by its strap

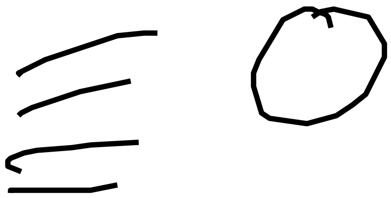
- draw and label all forces on object as vectors

Identifying Forces

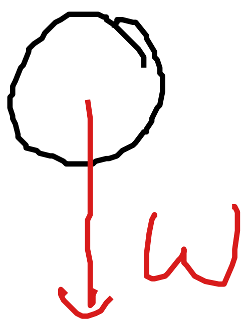
1) Weight
2) Look for all other objects touching the object.
   - table
   - strap
3) any surface of contact provides a normal force and maybe a frictional force
4) if there any ropes etc, add tension
5) if there are multiples use subscripts

N_{table} T_{strap}

Question: throw a ball across a room



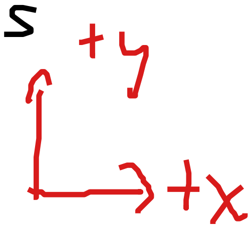
How many forces are acting on this ball? 1



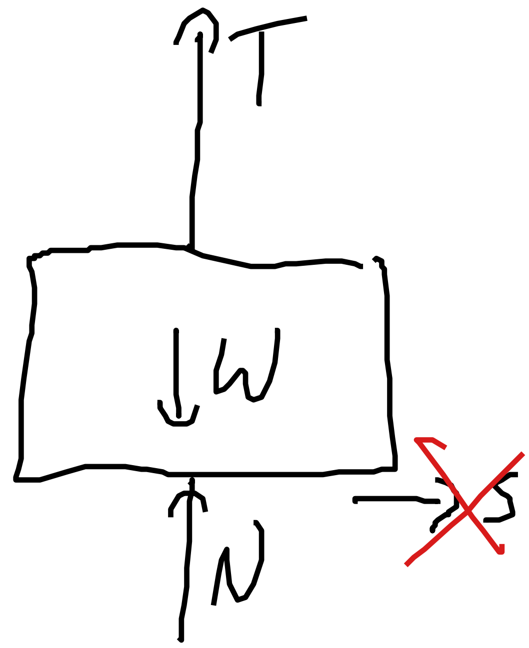
- nothing is touching the ball right now (except air – ignore!)

so no other forces

Solving force problems



	x	y
weight	0	−10
tension, strap	0	+T
normal, table	0	+N
+		
equilibrium	0	0



$W = 10N$

$y: \; -10 + T + N = 0$

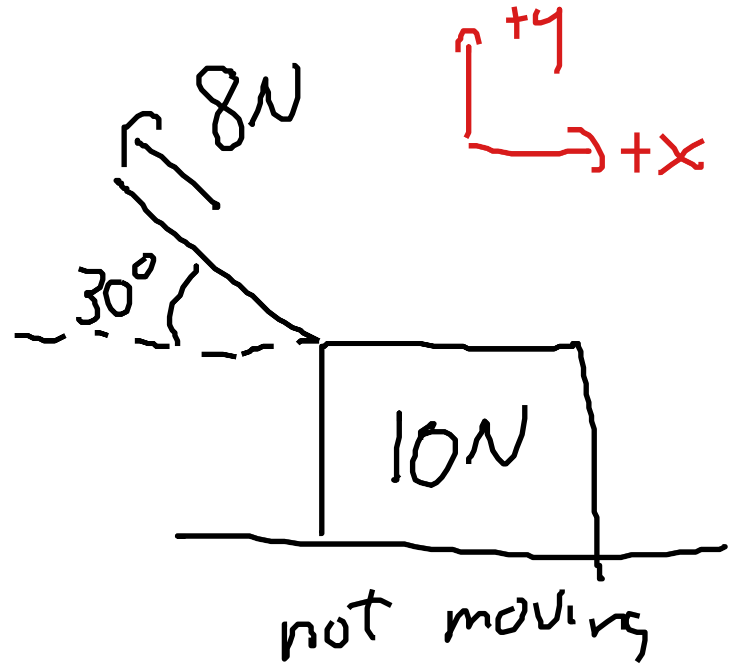
$T + N = 10$

I don't have enough information to solve: 2 unknowns, 1 equation

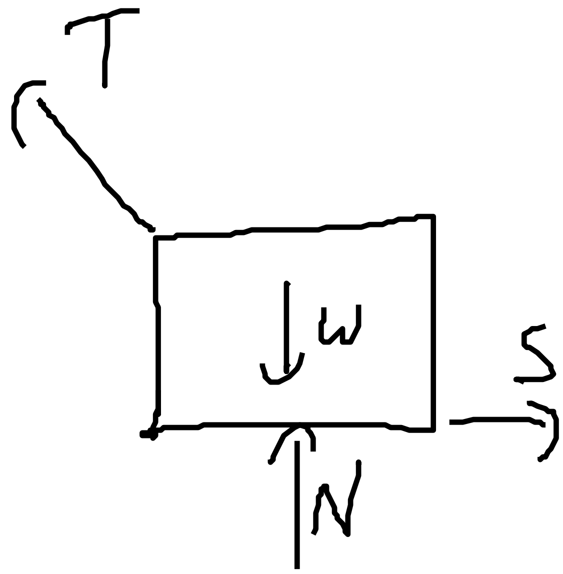
If I said $T = 6N$,

$$6 + N = 10$$

$$N = 4N$$



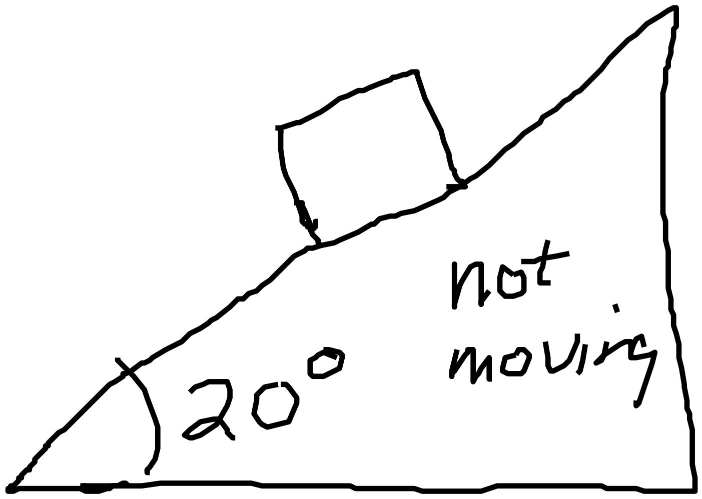
	x	y
weight	—	-10
tension, rope	$-8\cos 30^\circ$	$+8\sin 30^\circ$
normal, table	—	$+N$
s. friction, table	$+S$	—
equilibrium	0	0

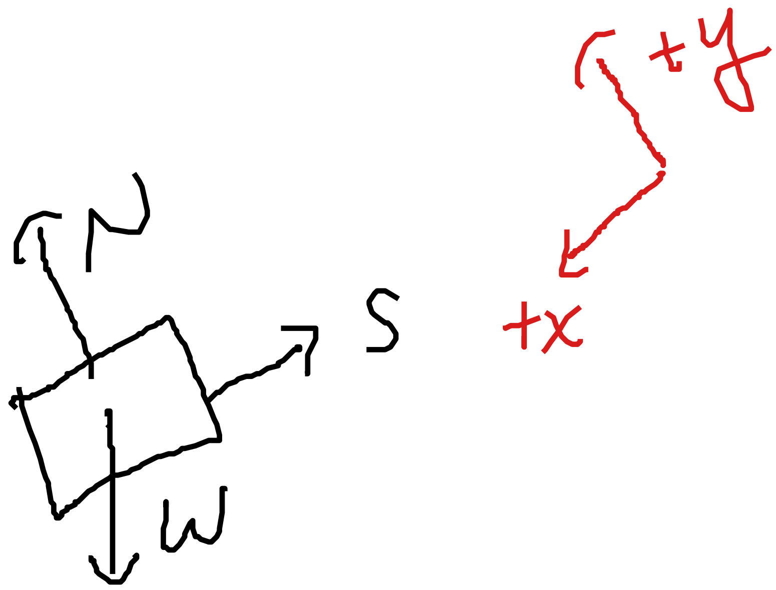


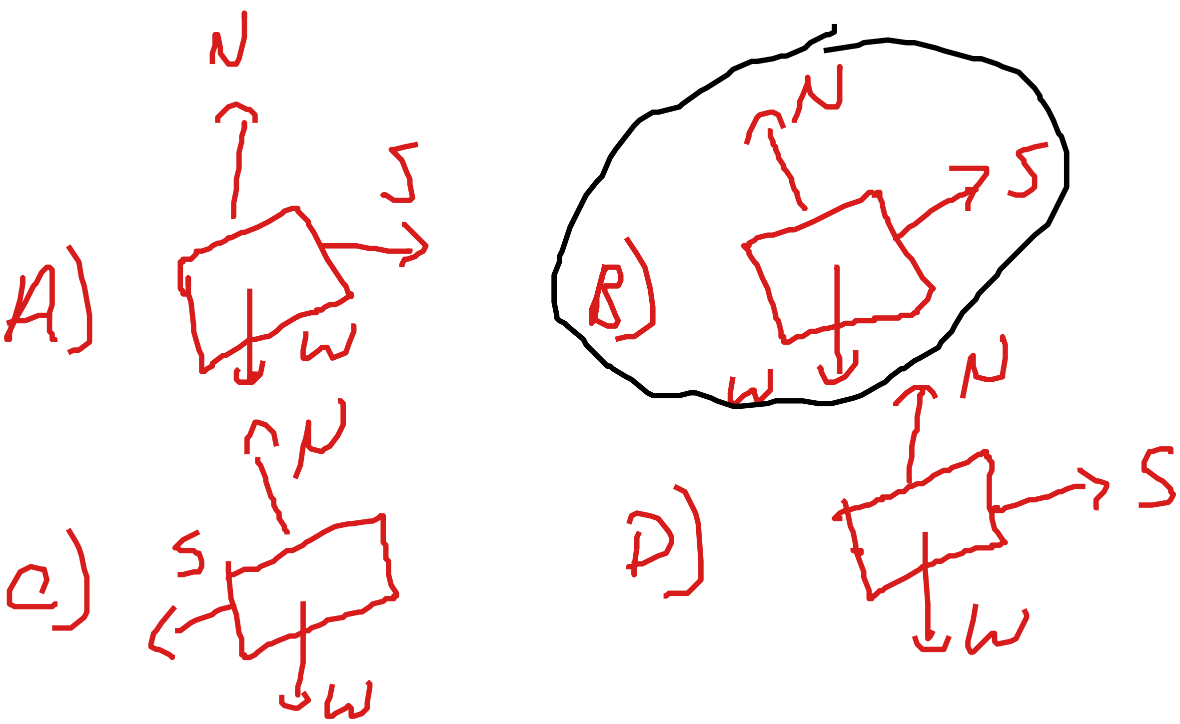
$$x: \; -8\cos 30^\circ + S = 0 \rightarrow S = 8\cos 30^\circ = 6.93\,N$$

$$y: \; -10 + 8\sin 30^\circ + N = 0$$

$$N = 10 - 8\sin 30^\circ = 6\,N$$


20°
not moving

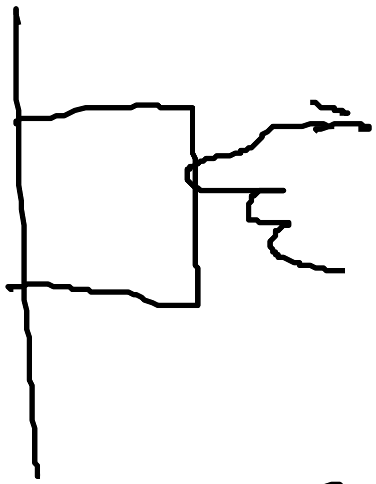

N
S
W
+y
+x

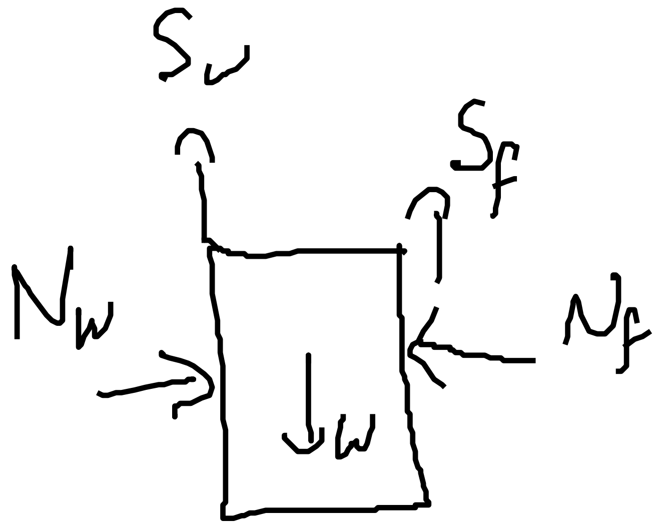

A)
N
S
W
B)
N
S
W
C)
N
S
W
D)
N
S
W

	x	y
weight	$+W\sin 20^\circ$	$-W\cos 20^\circ$
normal, ramp	—	$+N$
s. friction, ramp	$-S$	—
	0	0

$$W\sin 20^\circ = S$$

$$W\cos 20^\circ = N$$





up = down

$$S_w + S_f = W$$

weight

normal, wall

s. friction, wall

normal, finger

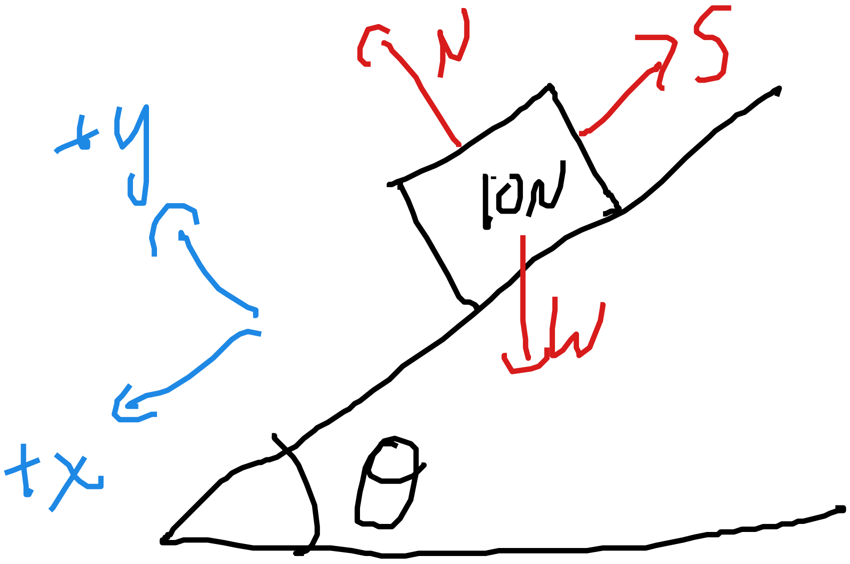
s. friction, finger

Static friction requires corresponding normal force

$$S \leq \underbrace{\mu_s N}_{S_{max}}$$

not sliping

μ_s: coefficent of static friction



For what values of θ will the block not slip?

weight	$+W\sin\theta$	$-W\cos\theta$
normal	0	$+N$
s. friction	$-S$	0

$S = W\sin\theta \qquad N = W\cos\theta$

$$S \le \mu_s N$$

$$\frac{W \sin\theta}{\cos\theta} \le \frac{\mu_s W \cos\theta}{\cos\theta}$$

$$\tan\theta \le \mu_s \quad \text{not slipping}$$

if $\theta = 10°$, $\tan 10° = 0.18$

$\mu_s > 0.18$

wood on wood: $\mu_s = 0.3$

rubber on dry concrete: $\mu_s = 1$

if $\theta = 45°$, $\tan 45° = 1$

$\mu_s \ge 1$

Newton's Second Law

if net force is not zero, the object accelerates

invisible cause

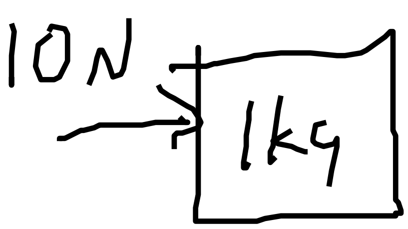
visible effect

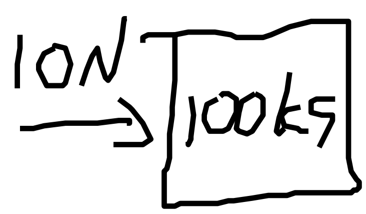
$$\vec{a} = \frac{\vec{F}_{net}}{m}$$

resistance to change

or

$$\vec{F}_{net} = m\vec{a}$$

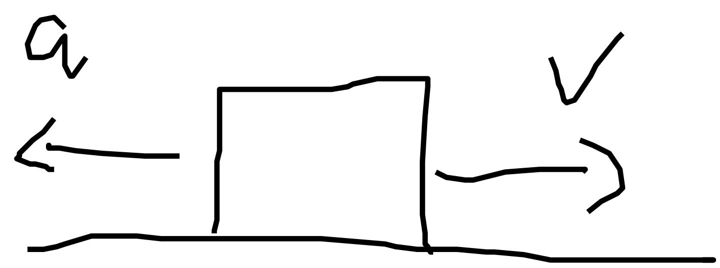




$$\vec{a} = \frac{10N}{1kg} = 10\,m/s^2$$

$$\vec{a} = \frac{10N}{100kg} = 0.1\,m/s^2$$

Push a block across a table, it comes to a stop Why?



Must have an $\vec{a}$ in opposite direction, therefore must be a force in opposite direction,

Kinetic Friction $\vec{K}$ points opposite the velocity

$$\boxed{K = \mu_K N}$$

not adjustable